On the role of variation of solar wind dynamic pressure in terrestrial oxygen outflows: FAST observations

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Previous observations have shown that the O+ ion population is an important contributor to the storm time ring current. Its abundance in terms of energy density increases with increasing geomagnetic activity. On the other hand, mechanisms of this dramatic composition change of the ring current are poorly understood. While enhanced polar outflows during geomagnetically active periods are considered to be responsible for the composition change, the link of the outflows and high-energy ring current is far from well understood. Recent studies have shown that the close relation between variations of the solar wind dynamic pressure and the plasma sheet and ring current O+ populations [Yao et al., 2008a]. Our previous study also showed the possible importance of the large dynamic pressure change, i.e., interplanetary shock (IPS) arrival to enhanced O+ supply to the inner magnetosphere during storm main phase.

The ESA [Carlson et al., 2001] and TEAMS [Klumpar et al., 2001] instruments onboard the FAST satellite had been operated in the mid-latitude regions above ˜45 degrees since 1998 and observed ions below 28 keV and 12 keV, respectively. The ESA can measure the ion pitch angle distribution with high time resolution, while TEAMS can resolve ion composition. At the radiation belt latitudes, high-energy particle contamination is quite uniform in energy. Utilizing this feature, we developed an automated method to subtract the radiation contamination from ESA data. Combining ESA and TEAMS data as in Seki et al., 2002, we have successfully obtained low energy ion data also in the inner magnetosphere. The data after the background correction show that O+ becomes the major ion component in the inner magnetosphere during large magnetic storms in the energy range below 28 keV. A distinctive feature of these data is that, preceding the development of the O+ ring current, an intense O+ ion population comprising multiple peaks at different energies in the distribution function appears in the early main phase. This characteristic feature is called as MIBS (multiple ion band structure), and it is known that the O+ MIBSs tend to be observed during storm main phase [Yao et al., 2008b]. In this study, we examined detailed feature of O+ MIBS events observed during storm main phase after IPS arrival so as to understand the role of change of solar wind dynamic pressure in O+ outflows.

During a storm beginning on April 11, 2001, for example, intense O+ MIBS below 12 keV were observed at low latitudes (50-60 degrees). The velocity ratio of higher-energy bands to the lowest energy band corresponds to 2, 3, 5, and 7, which suggests direct supply of these O+ ions from the ionosphere. The result of O+ trajectory tracings in empirical magnetic and electric field models of the magnetosphere (Tsyganenko 1996 and Weimer 1996 models) supports the inference: It shows that the velocity ratio of each energy band in the O+ distribution function is explicable with an intense broad-energy O+ outflow at the timing of the interplanetary shock arrival at the beginning of the storm and the subsequent velocity filter effect on closed field lines. The trajectory tracings also suggest that the ionospheric O+ are transported to the inner magnetosphere during the main phase, and contribute, at least partially, to the O+ ring current during the large magnetic storm. From the O+ velocity distribution data, we reconstructed the original outflow population and inferred the O+ outflow flux caused by the IPS arrival. On the basis of multiple events, we will discuss the effects of the size of the solar wind dynamic pressure change on the O+ outflow rate.